DESIGN AND ANALYSIS A CONTROL SYSTEM FOR 3 AXIS MECHANISM MACHINE

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SUPERVISOR'S DECLARATION

We hereby declare that we have checked this project and in our opinion this project is satisfactory in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering .

…….....

Name of Supervisor:

Position:

Date:

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurently submitted for award of other degree.

…….....

Name:

ID Number:

Date:

To my beloved father and mother

ACKNOWLEDGEMENTS

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ABSTRACT

A lot of applications using three axis mechanism machine to make the engineering process easier and efficiencies. Machine such as lathe, turning, milling and grinding are using this mechanism by applying automatic control system The thesis focus on the accuracy and positioning for AC Servomotor in three axis mechanism machine. All of the task would be control by Panasonic Driver which C programming language was utilized.This project is limited to low cost automation and low servo speed. The task of selecting one of which provides efficiently the required functionally for an application is a challenger. The ready availability of manufacturer product catalogues, outlining characteristics and rating of actuators helps in some cases. However, because of inconsistencies in manufacturer information, most engineers resolve to choose based an experience. From this project, the criteria in the selection aid focus in type of nature of control requirement by the application such as position control, speed control and torque control requirement. Proper actuator selection aids in achieving some low cost actuator goals and accuracy. Several term have been used to refer electric motor power electronics such as controller, amplifier, drivers, converter, and inverter depending on the drive of focus.

ABSTRAK

Aplikasi dalam mesin tiga paksi memberi kemudahan kepada proses kejuruteraan dan kejituan. Mesin seperti mesin pelarikan, pembelokan dan mesin pengisar yang menggunakan mekanisme ini selalunya terdapat dalam penggunaan sistem kawalan automatik. Tesis dalam kajian ini memfokuskan kepada kejituan dan keupayaan bagi AC Servomotor dalam penggunaan mesin 3 paksi. Segala tugasan dikawal oleh Panasonic Driver yang mana aturan C digunakan. Kajian ini terhad kepada aturan yang berkos rendah dan kelajuan motor yang rendah. Tugasan dalam menentukan kejituan dan ketepatan dalam penggunaan mesin kawalan merupakan satu cabaran. Garis panduan dalam kawalan motor yang disediakan oleh pembekal membantu dalam banyak kes. Bagaimanapun, disebabkan maklumat pembekal tidak konsisten, maka jurutera menyelesaikan masalah ini berpandukan pengalaman. Dalam kajian ini kriteria dalam pemilihan alatan kawalan memfokuskan kepada sistem kawalan, jenis kawalan seperti kawalan keupayaan, kawalan kelajuan dan kawalan tenaga putaran motor. Pemilihan aturan kawalan yang tepat memastikan penggunaan motor yang berkos rendah dan tepat. Beberapa penggunaan kuasa motor elektrik seperti pengawal aturan, amplifier,dan ’converter’, yang bergantung kepada fokus aturan.

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CHAPTER 1

INTRODUCTION

1.1 Project Background

Nowadays, three axis mechanism machine has been widely use in this world. A lot of applications are using this mechanism and make the engineering process easier and efficiencies. Machine such as lathe, turning, milling and grinding are using this mechanism by applying automatic control system and applied engineering devices with some sensors.

The introduction of three axis mechanism machine has changed the manufacturing industry by increasing the automation of manufacturing process which the improvements in consistency and quality has been achieved. In addition, these machines are more flexibility in time to produce different components.

Machine control is an important part in an automation control and the quality of the machining process is determined by machine control performance. Performing an optimum machine control is due to the complexity of machining process and hardware system. Considering both machining process and hardware system will make the machine control running better in real-time domain. Researcher investigated the use of linear motors as feed drives and showed that the quality of the machining are dependent on the interaction of the cutting process and the feed drive servo loop in a direct drive.

The main part in machining process is cutting force. A fundamental theory of model cutting force was developed by Martelloti and Tlusty. Tang et. al. and Zheng

et. al. were focused on cutting force for end milling, while cutting force for face milling was obtained by Kim and Ehmann and Cheng et.

The dynamic behavior of the system must be considered in analyzing cutting force to come out with optimal cutting parameter. Sutherland and DeVor, Montgomery and Altintas, Budak and Altintas, and Ismail et al. were analyzing cutting force with the effect of machine tool spindle.

1.2 Project objective

1. Design a control system for three axis mechanism machine.
2. Predict a servo speed by analyze the parameters and characteristics of tracking control of feed drive in machine.
3. Analysis the parameter of controllability (position control) for AC servo.

1.3 Project Scope

1. Design a control system and analysis the error in machine.
2. Data collecting for the conceptual design such as linear motion guide.
3. Testing and programming for machining setup.
4. Automation application be limited for low servo speed.
5. Using software **PANATERM** Panasonic Digital AC Servo Amplifier for parameter analysis.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction of control system

A control system is a device or set of devices to manage, command, direct or regulate the behavior of other devices or systems. There are two common classes of control systems, with many variations and combinations like logic or sequential controls, and feedback or linear controls. There is also fuzzy logic, which attempts to combine some of the design simplicity of logic with the utility of linear control. Some devices or systems are inherently not controllable.[1]

The term "control system" may be applied to the essentially manual controls that allow an operator to, for example, close and open a hydraulic press, where the logic requires that it cannot be moved unless safety guards are in place.

An automatic sequential control system may trigger a series of mechanical actuators in the correct sequence to perform a task. For example various electric and pneumatic transducers may fold and glue a cardboard box, fill it with product and then seal it in an automatic machine.[1]

In the case of linear feedback systems, a control loop, including sensors, control algorithms and actuators, is arranged in such a fashion as to try to regulate a variable at a setpoint or reference value. PID controllers are common and effective in cases such as this. Control systems that include some sensing of the results they are trying to achieve are making use of feedback and so can, to some extent, adapt to varying circumstances. Open-loop control systems do not directly make use of feedback, but run only in pre-arranged ways. [1]

2.2 Components of 3 axis machine

An axis is a direction of motion controlled by the CNC machine control. It can be linear (motion along a straight line) or circular (a rotary motion). The number of axes a machine has determines it's machining capabilities. For machining centers, a three axis machine will have three linear axes. A four or five axis machine will have three linear axes as well as one or two rotary axes.

The 3-Axis machine was designed to provide a suitable entry-level mechanism for experimentation with 3-axis machining and CAD/CAMM systems. It has not been designed to replace existing, higher end machines such as those produced by industrial company. The emphasis is on accessibility and allows the user to completely modify the in-built firmware on the machine. [2]

In order to fabricate a three axis mechanism machine, there is a need to determine which the components have to utilized so that it can perform smoothly and efficiency.

2.2.1 Linear Motion Technology

The systems and component that move, support, and guide loads move in linear directions. Also the term used to describe automated and semi automated mechanical systems that create Cartesian x, y, z axes of motion. Modern manufacturing process incorporate the use of linear component to allow for rapid , low- friction precision movement. A liner system combined with servomotor, driver, and sensor makes filling these requirements possible. Gear motors and servomotors used as the driving and controlling mechanisms provide feedback, control, and power to the system. Linear motion systems can be divided into three basic subsystems:

1. The drive or control
2. The thrust mechanism or actuator
3. The guideline or support components

The drive or control devices include a variety of electric motors such as linear, stepper, and servodrivers. The thrust mechanism, in conjunction with the drive, provides the thrust and axial positioning accuracy of the load. The guidance mechanisms of the systems control the travel direction and linear accuracy, as well as support the load.[2]

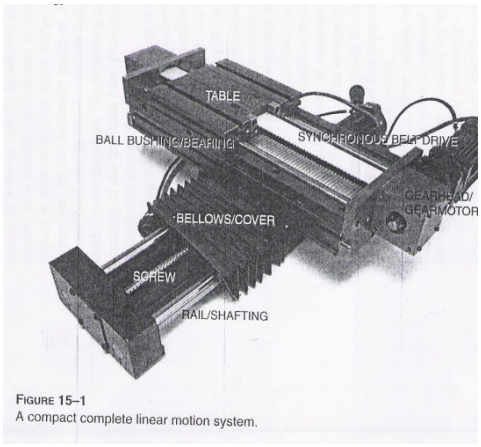

FIGURE 15–1
A compact complete linear motion system.

Figure 2.1 Linear Motor System

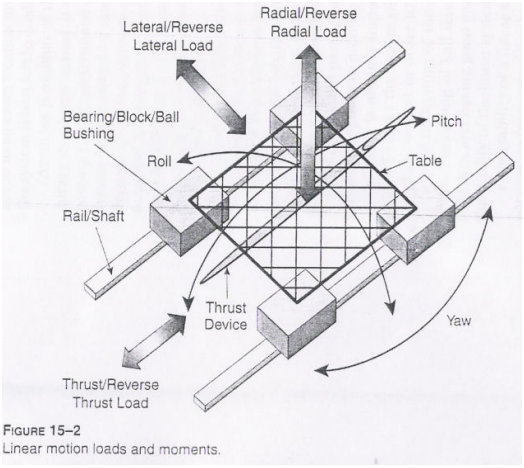

FIGURE 15–2
Linear motion loads and moments.

Figure 2.2 Linear Motion Load and Moment

2.2.1.1 Linear Slides

Linear slides is a precision products designed to control the physical movement of a manufacturing robot or an intermediate product under assembly. It can turn motion or torque into thrust. The actual directions and commands for the product positioning come from a computer that effectively control the entire manufacturing process. Application of' the linear slides is to move mounted mechanisms across a given axis either in one direction or combine of three or more directions. Complete linear slides normally consist of at least a base, a saddle, adjusting screws and a straight rib. Linear slides are resistant to contamination, extremely durable in shock load conditions and run smoothly on lightweight frames.

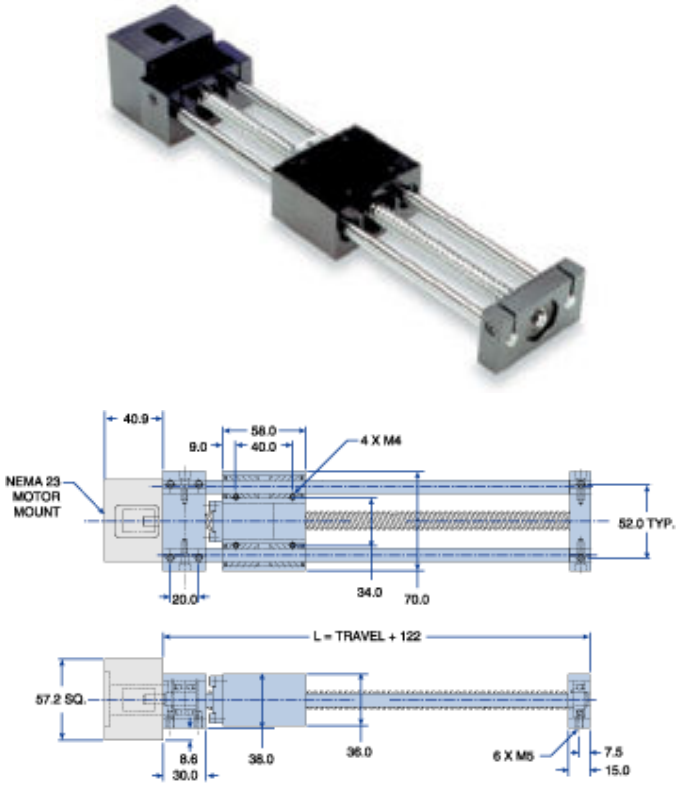

Figure 2.3 Linear Slides

By using linear slides,

(a) Products that having a wide range of weights, from lightweight miniatures to payloads of several hundred pounds can be move easily.

(b) Products can be move in distances that range from as little as 2.5 millimeters to 1.5 meters.

(c) Rapidly position their loads.

(d) They position their loads so precisely, that the final positioning can be measured in microns (millionths of a meter).[2]

Linear slides assemblies use non-recirculating precision balls and rollers that move against highly polished and hardened rod ways, greatly reducing friction. For immense loads and safe operation, dovetail linear slides will be appropriate. Ball bearing slides would be an appropriate choice if a self-lubricating slide with a smaller maximum load carrying capacity is required. Industries that require linear slides for high levels of precision in their manufacturing:

(a) lndustrial robots and machine tool assembly

(b) Fiber optics and photonics component building

(c) Manufacturing semiconductor and electronic equipment

(d) Medical equipment manufacture

2.2.1.2. Ball bearing slide (ball slides)

Most commons type of linear slides due to the self-lubricating qualities, which increase their reliability. Ball bearing slides are composed of two rows of balls on both sides of the base, the rows being contained by four rods. Functions of two rows of balls are to eliminate play and roll along the rods to create smooth, accurate, and low-friction motion. Thus, it can perform with a smooth linear motion; typically use four hardened and ground shafts that surround the balls at four different points.

The base length, base height, carriage length, carriage width, and top height specification to choose a particular ball slides. Larger slides can handle bigger loads, but the slide has to be able to fit into the housing or drive system. Ball bearing slides mostly use for delicate instrumentation, high-cycle applications, and clean room environments.

2.2.1.3 Dovetail slides

Dovetail slides are used in high load applications that require long travel distances and/or damping. Dovetail slides consist of a saddle or flaring tenor and a fixed base. Dovetail slides represent the simplest type of linear translation stages. They have relatively high stiffness and load capacity, and they can provide long travel. Dovetail slides are more resistant to shock than other bearings, and they are mostly immune to contamination.[4]

Compare to ball bearing slides, dovetail slides have direct contact between the base and saddle. Because of this fact, a greater farce is necessary to move the saddle and thus slowing acceleration rates. The amount of surface contact allows dovetail slides to be used in heavy load applications and various industrial uses. However, dovetail slides should not be used for high precision applications.

The dynamic load carrying ability, the number of inches per revolution of the screw (in dovetail slides with Acme, ball, or lead screws), maximum linear velocity of the carriage required, and the rate and distance of linear movement are an important specification when choosing a particular dovetail slide.

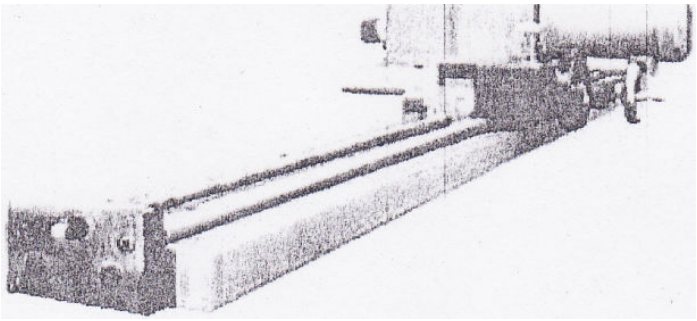

Figure 2.5: Dovetail Slides

2.2.1.4 Machine Slides

Machine slides are a type of linear slide that are used on various machines mostly in CNC machining. They are precision-designed to have close tracking tolerances. By using machine slides, high rigidity can be retained, which creates accurate linear motion for all applications. For machine slides, its have an adjustable ribs in order to make up for any irregular movements that may develop throughout an application.[4]

Machine slides can be single, double, or multi-axis, depending on their intended use. Mostly machine slides will conjunction with ball screws, lead screws, air cylinders, or hydraulic cylinders. Some of the standard types of machine slides include dovetail slides, hardened way slides, linear guide slides, and more.

Dovetail machine slides are used when occasional movement is needed in a positioning application for manual or powered movement. Hardened way machine slides are used in production for high-usage and heavy loads with little required maintenance for years. Of all machine slides, linear guide machine slides hold the highest load capacities for their size and have the lowest amount of friction.

Figure 2.6: Machine Slides

2.2.1.5 Roller Slides

Roller slides, of crossed roller slides have a simple construction, which use perpendicular rollers with a stationary base and moving carriage with higher load capacity than ball bearing. Its utilize rollers that crisscross each other at a 90° angle and move between the four semi-flat and parallel rods that surround the rollers. The rollers are between "V" grooved bearing races, one being on the top carriage and the other on the base. The design of' crossed roller slides allows them to carry up to twice the load of ball bearing slides and to absorb larger impacts or stackable to create multi-axis linear motion. In addition, roller slides are very versatile, as they can be adjusted for different uses.[6]

Figure 2.7: Roller Slides

2.2.1.6 Roller tables

Roller tables are the quietest type of bearing table and made up of a front sliding surface and rear sliding surface that are longitudinally aligned. For secure to rear supporting group, lifting levers are pivoted on a bearing bar. The levers have feeler pins engaged in sliding manners along guiding grooves, which are shaped so that when the front and rear supporting groups are moved away from each other.

2.2.1.7 XY table

XY tables are composed of forces and platens that usually contain motor mounting plates, couplings, lead screws, and a large base and top plate. The forcer glides over the platen on frictionless air bearings and moves continuously in a linear motion across the platen. It is because of linear motoring modules, typically between two and four, responding to currents.[2]

Variations among XY tables include the ways and the drive mechanism. While the drive mechanisms determine smoothness and speed, the ways determine load capacity, straight-line accuracy, and stiffness. Other factors imperative to XY tables are the accuracy, repeatability, and resolution required, as well as the appropriate motor for the application and whether or not an encoder is needed.

XY tables are most often mounted horizontally. Mostly used in applications such as water jet cutting, milling, and table sawing. XY tables may also be used in microelectronics assembly, laser machining and factory automation but depending on the specifications.

Figure 2.8 : XY Table.

2.2.2. Introduction of the Motor

Direct Current (DC) and alternating current (AC) motors are the two main types of electric motor. Both of motors can be differential by analyzing the how the electrical current is transferred through and from the motor. Both types of motors have different functions and uses.

DC and AC electric motors are important to everyday life. DC motors were introduced and caused a great revolution in the way many things are done. When AC motors came on the market the way motors were looked at changed because of their amazing starting power potential. [6]

2.2.2.1 DC motor

DC motors are widely used in application requiring accurate speed control, for example in servo systems. Dc motors come in two general types, they can have brushes or be brushless.

DC motors feature a speed, which can be controlled smoothly down to zero, immediately followed by acceleration in the opposite direction without power circuit switching. Brush DC motors use rings that conduct the current and form the magnetic drive that powers the rotor. Brushless DC motors use a switch to produce the magnetic drive that powers the rotor. Direct current motors are often found in appliances around the home.